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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAM OF THE

NEW HAVEN MEETING

AT

YALE UNIVERSITY

JUNE 23, 24 and 25, 1932

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The American Physical Society

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BULLETIN

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AMERICAN PHYSICAL SOCIETY

NEW HAVEN MEETING, JUNE 23–25, 1932

The 179th meeting of the American Physical Society will be held in New Haven, Connecticut, at Yale University, on Thursday, Friday and Saturday, June 23, 24 and 25, 1932, as a joint meeting with the Applied Mechanics Division of the American Society of Mechanical Engineers.

The first session will begin on Thursday morning, June 23, at 9 o'clock in the Sloane Physics Laboratory.

CALENDAR

Eastern Standard Time

Wednesday, June 22

2:00–8:00 P.M. Hotel Taft: Registration.
Sloane Physics Laboratory: Registration.
Phelps Gateway: Yale University room assignments.

Thursday, June 23

7:00–12:00 A.M. Hotel Taft: Registration.
Sloane Physics Laboratory: Registration.
Phelps Gateway: Yale University room assignments.

9:00 A.M. Sloane Physics Laboratory (S.P.L.)
Room 56: A.P.S.; Contributed papers 1–9.
Room 57: A.S.M.E.; Hydro- and Aerodynamics Session.
Room 59: A.P.S.; Contributed papers 10–22.
Osborn Zoological Laboratory (O.Z.L.)
Room 126: A.P.S.; Contributed papers 23–32.
Room 360: A.P.S.; Contributed papers 33–41.

12:00 Noon New Haven Lawn Club: Luncheon (seventy-five cents).

12:00 Noon Faculty Club: Ladies' Luncheon (fifty cents).

1:00 P.M. Sloane Physics Laboratory
Rooms 48, 51, 52, 56, 57, 63, 65: A.P.S.; Conferences as announced.
Room 59: A.S.M.E.; Vibration Session.

1:30–3:30 P.M. Sterling Memorial Library: Special exhibits; tours of inspection.

3:30 P.M. Sterling Memorial Library: Tea, out-of-doors if weather permits.

4:30 P.M. Sloane Physics Laboratory: Registration.

5:45 P.M. New Haven Lawn Club: Dinner.
Tickets ($1.50) must be procured at time of registration.

8:00 P.M. University Theatre: "The Perfect Alibi," A. A. Milne; presented by the Yale Dramatic Association. Tickets (no charge) must be procured at time of registration.

Friday, June 24

8:00 A.M. Osborn Zoological Laboratory
Room 102: A.P.S.; Invited papers

8:00 J. A. Gray, F.R.S.: "Wave-Length of Scattered Radiations."

8:40 J. W. M. DuMond: "Experimental Evidence for High Electron Momenta in Atoms and in Solid Bodies."

9:30 J. A. Bearden: "Status of X-Ray Wave-Lengths."

10:10 J. D. Hanawalt: "Fine Structure of the *K*-Absorption Edge."

10:50 Discussion: led by Bergen Davis.

8:30 A.M. Sloane Physics Laboratory
Room 59: A.S.M.E.; Stress Analysis Session.

9:00 A.M. Ladies' Sight-Seeing; Motor Tours; Golf; Tennis.

12:00 Noon New Haven Lawn Club: Luncheon (seventy-five cents).

12:00 Noon Ladies' Luncheon to be announced.

1:00 P.M. Sloane Physics Laboratory
Rooms 48, 51, 52, 56, 57, 63, 65: A.P.S.; Conferences to be announced.
Room 59: A.S.M.E.; Elasticity and Plasticity Session.

2:00 P.M. Sloane Physics Laboratory: Tours of inspection to be announced.

3:30 P.M. Double Beach: Sea bathing, sports.
Beginning at 3:00 private cars will be loaded and dispatched from the south side of Humphrey Street between Whitney Avenue and the entrance to the New Haven Lawn Club.

5:40 P.M. New London: Boat-Race Train ($5.00). Tickets may be obtained by *advance registration only*.

6:00 P.M. Double Beach: Picnic Supper ($1.25). Tickets must be procured at time of registration.

Saturday, June 25

8:30 A.M. Osborn Zoological Laboratory
Room 102: Joint Session A.S.M.E. and A.P.S.;
Invited Papers

F. Zwicky: "Mosaic Structure of Crystals."
F. Bitter: "Magnetism and Plasticity."
R. L. Wegel and H. Walther: "Dissipational Resistance to Distortion in Solid Bodies and its Correlation with other Physical Properties."

9:00 A.M. Ladies' Sight-Seeing; Motor Tours; Golf; Tennis.

12:00 Noon New Haven Lawn Club: Luncheon (seventy-five cents).

1:00 P.M. Sloane Physics Laboratory

Rooms 48, 51, 52, 56, 57, 63, 65: A.P.S.; Conferences as arranged.

Room 59: A.S.M.E.; Thermal Stresses Session.

Railroad Rates

Any person attending the meetings of the American Society of Mechanical Engineers or the American Physical Society may take advantage of the reduced railroad rates, on the usual certificate plan. The traveler should purchase a one-way, full-fare, through ticket to New Haven, and secure at the same time from the agent a certificate. This certificate must be validated at the registration desk at the time of the meeting; it will then entitle the owner to a return ticket by the same route without stop-over at half the full fare, within the usual time limits.

Members should consult their local ticket office for information.

Headquarters. The headquarters for the Physical Society will be the Hotel Taft.

Registration

Members are requested to register as soon as possible on Thursday morning at the Hotel Taft.

As authorized by the Councils of the societies concerned *a registration fee of one dollar* will be collected from each adult in attendance. Any cash balance on hand after all bills are paid will be divided, on the basis of registered attendance, between the societies concerned.

Those arriving by train or bus will find it more convenient to register for the meeting at the Hotel Taft no matter where they have reserved rooms. The Taft is at the south-west corner of the Green at the intersection of Chapel Street and College Street.

Those driving their own cars may find it more convenient to register at the Sloane Physics Laboratory, where much more parking space is available. The S. P. L. is reached from the Taft by going north on College Street three blocks to Grove Street (traffic light) bearing left on Prospect Street crossing Trumbull and Sachem Streets and looking for signs on the right at 0.8 mile from the Taft.

Accommodations

A limited number of rooms in University dormitories will be available for single occupants, either men or women. Small groups of rooms having one entrance will be assigned to men only or to women only, so that husband

and wife applying for dormitory rooms will be housed separately. The charge for each room will be $1.50 per night, and preference in assignment will be given to those who register for more than one night's lodging. Meals are not served in these dormitories, but lists of suitable eating places at no great distance will be furnished. University rooms may be occupied Wednesday afternoon, June 22, and must be vacated Sunday morning, June 26.

Besides the dormitories there will be available a considerable number of single rooms in the New Haven Y.M.C.A. and a few rooms in the Y.W.C.A. These fine new buildings form a single group with an excellent cafeteria in common. Charges, as given below, are about the same as for University rooms.

Other hotel accommodations are listed below:

Hotel Taft—(Headquarters) capacity 400 (Rates include Breakfast): single rooms, $4.25 to 4.75; double rooms, 7.50 to 9.00; three or more in one room, 4.00 each.

Hotel Garde—capacity 200: single rooms, $2.50 to 3.50; double rooms, 3.50 to 6.00.

Hotel Duncan—capacity 75: single rooms, $2.00 to 3.00; double rooms, 3.50 to 6.00.

Hotel Bishop—capacity 40: single rooms, $3.00; double rooms, 5.00.

Y.M.C.A.—available capacity 125: single rooms, "1.25 for members of Y.M.C.A.; 1.50 for non-members; 1.00 after 2nd day.

Y.W.C.A.—available capacity 25: single rooms, $1.25 to $1.50.

New Haven Lawn Club. The Board of Governors of the New Haven Lawn Club has extended to registrants the privileges of guests. This means that meals will be served at any time during which the grill room or restaurant is open, and that free use may be made of all general club rooms. It is expected that many attending the meetings will have lunch at the Club, which is within five minutes walk of the Sloane Physics Laboratory and has extensive parking spaces. A special luncheon (seventy-five cents) will be served every day that the demand warrants it, and early announcement of intention to lunch at the Club will be necessary in order to assist the steward in planning this service. A regular luncheon (seventy-five cents in the grill room, à la carte in the restaurant) is available in case the special luncheon is not sufficiently in demand.

Information

Mail, Telephone, Telegraph. On Wednesday afternoon and Thursday morning information can be obtained at the two registration desks (Hotel Taft and Sloane Physics Laboratory). After Thursday noon all inquiries should be made at the Sloane Physics Laboratory (Telephone 3–6600, extension 235). Incoming messages should all be addressed to the Sloane Physics Laboratory. Outgoing telegrams and telephone messages can be sent from the Laboratory and from the Lawn Club at any time.

Parking. Many New Haven streets are narrow and parking in some places is limited to very short periods. Please look carefully for police signs to avoid embarrassment. Twenty-four hour parking is not permitted in any

part of town. University parking spaces—even if inhospitably placarded—will be open as far as possible to guest cars carrying identifying stickers issued to registrants.

Map. A map, showing buildings used during the meetings, eating places near the dormitories, parking places and other matters of interest will be furnished to registrants.

Entertainment

Sterling Memorial Library. Inspection of the Library Thursday afternoon will be under guidance of library employees familiar with its many departments and activities. Special exhibits of early maps and scientific books are being arranged through the courtesy of the Librarian and his staff. Tea (or equivalent refreshment) will be served without charge in the open court within the building or, if the weather does not permit this, in the large entrance hall. It is hoped that everyone attending the meeting will make an effort to be present.

Dinner and Theatre Party. Tickets for the dinner ($1.50) on Thursday evening must be procured at the time of registration. The dinner will be brought to a close in plenty of time for walking to the University Theatre if weather permits. In case of inclement weather drivers of cars will be asked to assist in transporting the audience to the theatre. The performance, a special one conplimentary to our members, is contributed to our entertainment by the President and Fellows of Yale University.

Ladies' Program. It is hoped that visiting ladies who are not fully occupied with the technical program will frequently consult the Bulletin Boards in the Sloane Physics Laboratory and the New Haven Lawn Club where notices of especial interest to them will be kept posted.

Children. Parents are invited to leave their young children at the Faculty Club, under competent supervision, during their attendance upon technical or social events (except the Double Beach outing on Friday).

Sight-Seeing Trips. Guides to the older and newer University Buildings leave Phelps Gateway at reasonably frequent intervals. Special trips can be arranged upon request.

Motor Tours. Roads to and about New Haven are in general very good so that members are urged to bring their cars. Arrangements for garage service and parking will be made, and the availability of numerous guest cars for transportation will reduce the cost of the meeting to all concerned.

Several circular tours, starting and terminating in New Haven, have been planned for our guests and copies of the itineraries will be supplied to those interested. Members of the A.A.A. are invited to make use of the Connecticut Motor Club at 32 Whitney Avenue, (between Grove Street and Trumbull Street).

Those driving to New London (50 miles) to view the Yale-Harvard Boat Race either from the observation train or from their own cars should allow plenty of time for the trip as the roads into New London are likely to be crowded.

Golf. The following list includes the principal links available in and near New Haven. The finest is the Yale Golf Course which should prove of especial interest to low-handicap men. Directions for reaching any of those listed may be obtained on registration by those interested. Greens fees are payable at the links in each case.

ADVANCE REGISTRATION CARD

NEW HAVEN MEETING, JUNE 23–25, 1932

Please return this card during the first week of June if you then expect to attend the meeting.

Name.....
Last name First name Other initials

Address for reply: June 8 to June.....

Others in party:.....men .....women .....children (*give ages*)

Will arrive about.....A.M./P.M. June..... by Train ☐ Bus ☐ Automobile ☐.

Will remain until about.....A.M./P.M. June.....

If house guests give name of host.....

If University rooms are desired how many.....

Hotel rooms have been { obtained / requested } at

☐ Taft ☐ Garde ☐ Duncan ☐ Bishop ☐ YMCA ☐ YWCA

Reserve .....dinner tickets, ...outing tickets or .....boat-race tickets.
(June 23) (June 24) (June 24)

Arrange conferences, if possible, on.....

Yale Golf Course	18 holes	$2.00*
* Special rate to registrants only		
New Haven Country Club	18 holes	4.00
Race Brook Country Club	18 holes	3.00
Meadow Brook Country Club	18 holes	1.00 morning
		1.50 afternoon—
	($2.00 Saturday and Sunday)	
Orange Hill Club	18 holes	.50 morning
		1.00 afternoon
Giant Valley Country Club	9 holes	.75
New Haven Municipal Links	9 holes	.35

Tennis. The New Haven Lawn Club has numerous courts to which registrants are welcome at any time *before* 4:00 P.M. The Yale courts are open to the public at the time of the meeting and so cannot be reserved in advance. If enough registrants are interested in competitive tennis a tournament may be arranged.

Changes in Plans

The advance registration card is reprinted on p. 8. In case the information already furnished should be altered, or if the original card has been lost and you *now* expect to come to the meeting please tear out the rest of this page and send it, suitably filled out, to Professor L. W. McKeehan, Sloane Physics Laboratory, Yale University.

Abstracts. Titles and abstracts of papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction they will be published in an early number of the Physical Review. Authors should send corrections to the Editorial Secretary, The American Institute of Physics, 11 East 38th Street, New York, New York.

Other meetings for the current season are as follows:

180. Chicago. November 25–26, 1932.
181. Pasadena. December 16–17, 1932. Pacific Coast.
182. Atlantic City. December 28–30, 1932. Annual Meeting.
183. February 23–25, 1933. New York City.
184. April 27–29, 1933. Washington.

W. L. Severinghaus, *Secretary*
Columbia University

April 9, 1932

THURSDAY MORNING AT 9:00 O'CLOCK

Sloane Physics Laboratory, Room 56

Papers No. 8 and 9 will be read by title.

1. Theory of variation of paramagnetic anisotropy among different salts of the iron group. J. H. VAN VLECK, *University of Wisconsin.*—Experimentalists find that nickel salts are magnetically isotropic to about one percent, but that those of cobalt have anisotropy amounting to around 30 percent. A theoretical explanation is given for this difference, which at first sight is puzzling because both the Ni^{++} and Co^{++} ions have F ground terms (respectively $f^8\ ^3F$ and $f^7\ ^4F$). Suppose the crystalline potential of the form $Ax^2+By^2-(A+B)Z^2+D(x^4+y^4+z^4)+f(r)$ where the rhombic or second order terms are small compared to the "cubic" or fourth order ones, as indicated by the recent investigations of Jordahl, Penney, and Schlapp (Phys. Rev. May 15, (1932)). Then by joint adaptation of the Bethe group theory of crystal Stark effect and the Goudsmit-Slater method of diagonal sums it is shown that the energy diagram connected with the splitting in the crystal field is inverted for Co^{++} as compared to Ni^{++}, so that a state which is nearly isotropic magnetically is the ground state for Ni^{++}, whereas an anisotropic one is the normal level for Co^{++}. The inversion phenomena are also discussed in connection with other ions of the iron group in which it appears. The nearly perfect isotropy of manganous salts is trivial, as Mn^{++} is in an S state.

2. Monocrystal Barkhausen effects in rotating fields. F. J. BECK AND L. W. MCKEEHAN, *Yale University.*—The directions of Barkhausen effects in a single crystal disk of silicon steel, held stationary in a magnetic field rotating slowly in the plane of the disk, have been determined. Search coils at right angles picked up impulses proportional to selected rectangular components of the changes in magnetization. Measurements on an oscillographic record were made at two values of induction: 1480 and 645. Values of the angle Φ between the change in magnetization ΔI and the corresponding variation in the applied field, $(dH/dt)\Delta t$ are determined for various positions of the applied field relative to the crystallographic axes. The normal to the disk made angles of 30°, 60°, 90° with these axes. For these low values of induction the effects are mainly transverse and are more nearly transverse for the greater value of induction. The average value of Φ is about 20° (ΔI lagging) for the lower value of B and is less than 5° for the higher value. Individual values of Φ for one setting differ by as much as 30°. The average magnetization apparently lags the applied field and makes a small angle with it. The direction and frequency of effects seemed unaffected by changing the direction of H in the plane of the disk.

3. Mechanical hardness influenced by magnetism. S. R. WILLIAMS, *Amherst College, Amherst, Mass.*—About a year ago, Herbert published a most interesting article on "magnetic hardening of metals," (American Machinist **74,** 967, 1931). Not only did he find that rotating a ferromagnetic substance in a magnetic field changes the hardness but that the same thing occurred for substances which are not ferromagnetic. This work of Herbert's confirms some observations on steel rods, made by the writer in 1924, (Williams, Trans. A. S. S. T., p. 362, 1924). The work of 1924 has been repeated and confirmed on a series of high carbon steel rods of different drawing temperatures. The study has been extended to a series of steel rods of different carbon content and hardness. The effect seems to be very clearly shown. Magnetostrictive effects have been the means for studying the changes in hardness due to magnetic fields.

4. The dielectric constant of liquid sulphur. H. J. CURTIS, *Yale University.*—The dielectric constant and power factor of liquid sulphur was measured by a bridge method at four different audio-frequencies and over the temperature range 118°C to 350°C. The dielectric constant was found to be independent of frequency and equal to 3.520 ± 0.010 at 118°C. The specific polarization is independent of temperature between 118°C and 158°C and equal to 0.2528 ± 0.0008 cm^3g^{-1}. Above 158°C the polarization decreases directly as the reciprocal of the absolute

temperature, showing that molecular association occurs with very strong binding forces between the molecules. This shows that liquid sulphur is definitely nonpolar. A method was developed for differentiating between that part of the power factor which is due to conductivity and that which is due to molecular friction. The former was found to be very large, especially at high temperatures, and the latter very small at all temperatures. This is a further confirmation of the fact that sulphur is nonpolar. The infrared spectrum of liquid sulphur contains definite absorption bands, which shows that its molecules are polar. It is difficult to understand this contradiction, since both measurements seem to give conclusive results.

5. Dielectric constant and particle weight. J. W. WILLIAMS, *University of Wisconsin.*—Svedberg has been successful with the determination of the size and weight of colloidal particles by observing their linear velocities when subjected to a centrifugal field. A similar result should follow from a study of their rotational velocities in an alternating electrical field. The method, an application of the dipole theory of Debye, depends upon the fact that owing to the frictional resistance of the medium to the rotation of the suspended particles a finite time is required for their orientation in the field. If the frequency dependence of the dielectric constant is determined for a system composed of electrically dissymetrical particles supended in a liquid medium there will be found to be a region in which the dielectric constant decreases as the frequency is increased. The theory expresses the size, and therefore the weight, of the suspended particle in terms of the observed critical frequency and the "viscosity" of the medium. The available data are as yet insufficient for the exact determination of the particle size because the systems involved fail to conform to the assumptions underlying either the law of Stokes or the Clausius-Mosotti relation. Nevertheless, calculations from them indicate that once it becomes possible to evaluate the true inner friction constant of the system important results may be obtained. The method readily distinguishes monodisperse and polydisperse sols.

6. Surface charge of large particles in liquids. HAROLD A. ABRAMSON, *Columbia University, and* HANS MUELLER, *Massachusetts Institute of Technology.*—It is proposed that an advance in the study of the constitution of the solid-liquid and liquid-liquid interfaces may be made by calculation of σ, the surface density of electric charge, in addition to the analysis of the potential difference, ζ, between the movable phases. For large particles σ can be readily calculated by an extrapolation of the Debye theory. This has been done for the negatively charged surfaces of graphite, glass, cellulose, "collodion" and paraffin oil, in the case of ions (valence 1:1; 1:2; 2:1; 1:4) not producing reversal of sign of charge. Although the ζ-concentration curves are rather complex, the σ-concentration curve in every case yields a simple curve resembling typical adsorption with an initial steep slope and with saturation at salt concentrations of about 0.01 molar. Curves of this type have been predicted by Stern. The character of the curves is determined by both ions. The slope at zero concentration varies markedly, particularly with the nature and valence of the anion; e.g., for glass in the order $I > Br > Cl$, the differences diminishing as saturation approached. The method of calculation employed here to ascertain the nature and magnitude of the forces involved in adsorption of ions by "inert" surfaces at the liquid interface is justified by previous theory and experiment of the authors.

7. Some remarks on the physical constants of cells in connection with their size and shape. N. RASHEVSKY, *Westinghouse Research Laboratories, East Pittsburgh.*—In a paper presented at the Cambridge meeting, (Physics **2**, 303, 1932) a formula was deduced, giving the size of a cell in terms of its physical constants, such as, the coefficient of diffusion for oxygen, permeability, surface tension and rate of metabolism. From values for the diffusion coefficient D as found for muscle tissue, values of the order of magnitude of 10^{-3} cm for the size were found. Bacteria, however, are much smaller, and in order to account for their size, values for D about 1000 times as small must be assumed. It is interesting, that in a recent investigation Professor R. W. Gerard arrived at a similar conclusion from an entirely different point of view; namely, from the study of oxygen consumption. He discarded, however, the assumption of such a small D, as being not supported by any other facts, and interpreted his experimental results otherwise. Questions as to the possible reason of such a small D in bacteria are discussed in the present paper. Furthermore, some applications of the author's foregoing studies to the problem of shape of certain cells are made.

8. Electric phase angle of cell membranes. KENNETH S. COLE, *Columbia University.*—From the theory of an electric network containing any combination of resistances and a single variable impedance element having a constant phase angle independent of frequency, it is shown that the graph of the terminal series reactance against the resistance is an arc of a circle with the position of the center depending upon the phase angle of the variable element. If it is assumed that biological systems are equivalent to such a network, the hypotheses are supported at low and intermediate frequencies by data on red blood cells, muscle, nerve, onion membrane and potato. For some tissues there is a marked divergence from the circle at high frequencies, which is not interpreted.

9. A theory of surface conductance at an electrolyte-solid interface. KENNETH S. COLE, *Columbia University.*—An expression has been derived on the basis of the Maxwell-Boltzmann distribution and Poisson's equation for the tangential surface conductance of an electrolyte in contact with a charged plane surface. One part of this expression is analogous to the result given by Smoluchowski for a Helmholtz double layer, while the second part arises from the movement of the ions in the diffuse ion cloud under the applied electric field. The theory shows qualitative agreement with the data of Briggs for the conductance of univalent chloride solutions at a cellulose surface. For all but the most dilute solutions, the Smoluchowski term is negligible and the surface conductance is proportional to the charge density on the surface. The theory does not agree with the data for different anions and it is suggested that the decrepancy may be due to adsorption phenomena. There may be a movement of the adsorbed ions or of a diffuse ion cloud resulting from the presence of adsorption potentials at a distance from the interface.

PROGRAM

For Sessions of the American Physical Society

THURSDAY MORNING at 9:00 O'CLOCK

Sloane Physics Laboratory, Room 59

10. Photographic reciprocity and intermittency defects near the long wavelength limit of plate sensitivity. BRIAN O'BRIEN AND VERNON L. PARKS, *Institute of Optics, University of Rochester, N. Y.*—Previous work on compensation of reciprocity failure in photographic spectrophotometry by intermittency defect imposed on light beam of higher intensity by interrupted exposure [Phys. Rev. **33,** 640 (1929), Phys. Rev. **37,** 471 (1931)] has been extended to the long wave-length limit of plate sensitivity (λ10,000A for one emulsion) where both defects become large. The four emulsions used, Eastman Process, Process Panchromatic, Contrast Bromide, and Infrared Sensitive 3Q, all exhibit large reciprocity failure. A tungsten incandescent source was maintained constant within 1/4 percent, and mounted on a carriage with range of movement of 50 meters for varying intensity. Fixed sectors were used with aperture ratios of 1/40 to 1/1212, running 28 flashes per second. Errors in measurement of sector apertures and exposure timing were less than 1/2 percent. Although reciprocity failures were as great as 0.92 in density, the difference in density produced on adjacent areas by continuous low intensity and interrupted high intensity exposure (for It=const.) in no case amounted to a difference in log exposure greater than 0.012, and average difference was less than 0.004. Although just within the limit of measurement this appears to be a systematic difference with reciprocity defect greater than intermittency defect, but difference, if real, is so small that it may be neglected in photographic photometry.

11. The absorption spectrum of sulfur dioxide. J. A. DUNCAN, *Columbia University* (*Introduced by Harold C. Urey*).—The absorption spectrum of sulfur dioxide has been photographed in the region λλ2165–2410A with a Hilger E185 quartz spectrograph having a dispersion of about 1A per mm. The bands are partially resolved into rotational band lines. In this work an effort has been made to analyze the rotational structure rather than the vibrational

structure, since Chow (Bull. of the Am. Phys. Soc. Vol. 7 No. 2, 19, April 12, 1932) using lower dispersion is working on the latter problem. The more intense lines of some bands can be classified into branches having approximately constant second differences. These bands appear to fall roughly into two classifications; (1) bands consisting of only one branch resembling a Q branch; (2) bands consisting of two or more branches. It is found to be possible to include in this way nearly all the strong lines of these bands.

12. The alternation of intensities in the sodium bands. JOSEPH JOFFE, *Dept. of Chemistry, Columbia University.* (*Introduced by Harold C. Urey*).—A study has been made of the relative intensities of the Q branch lines from $J=45$ to $J=71$ of the (0, 2) band of the $^1\Pi \rightarrow {}^1\Sigma$ band system using the second order of a 21-foot concave grating with 15000 lines to the inch. Density marks were put on the plates by oscillating screens, as described by Harrison. The difficulties encountered are: (1) difficulties in resolving lines; hence the few lines studied; (2) the necessity to use pressure broadening to secure true relative absorption coefficients; (3) a number of absorption lines not belonging to this band falling in the same region. Three plates taken, the sodium vapor being mixed with 2, 28, and 103 millimeters pressure respectively of nitrogen gas give 1.65, 1.74, and 1.86 respectively for the ratio of intensities of the odd to the even lines. A consideration of possible errors leads to the conclusion that the spin of the sodium nucleus may be either 3/2 or 1, though the latter value appears to be the more probable and is that required by the depolarization of resonance radiation (Heydenburg, Larrick, and Ellett. Bull. Am. Phys. Soc. **7,** No. 2, 21 (1932)). Further work is in progress.

13. The continuous absorption spectrum of chlorine. G. E. GIBSON AND NOEL S. BAYLISS, *The University of California, Berkeley, California.*—A photographic method was used to investigate the continuous absorption spectrum of chlorine at six different temperatures. The effect of increasing the temperature is to decrease the absorption coefficient at the maximum and to broaden the region of continuous absorption. The results were analysed to obtain the individual contributions of the first two vibrational levels of the normal electronic state to the total absorption. Plotted against wave number, the absorption from the lowest level, ($v''=0$), has a form similar to that of a Gauss error curve, and the absorption from the next level, ($v''=1$), has two maxima. The results are in qualitative accord with a theory of continuous absorption developed by Gibson and Rice.

14. The origin of the mercury bands at 2480A. J. GIBSON WINANS, *University of Wisconsin.*—The mercury bands near 2480A were photographed under different excitation conditions with the purpose of determining their origin. A discharge through mercury vapor was produced in a quartz tube through external electrodes by a low voltage Tesla coil. A photograph of the 2476 band in the third order of a 21-ft. grating checked that of Miss Brozowska, (Zeit. f. Physik **63,** 557 (1930)). Five different tubes containing distilled mercury showed the entire group of eight bands. These bands were weakened by heat. From these observations the origin is some form of mercury molecule, the most probable being Hg_2 or Hg_2^+. Six lines of evidence favor Hg_2^+ over Hg_2: (1) observations on fluorescence, (2) comparison of intensities in mercury arc and electrodeless discharge, (3) comparison of the intensities of the 2476 and 2345 bands under strong and weak field excitation, (4) abscence of other bands of similar character in the mercury spectrum and the observation by Rayleigh that these bands do not appear in absorption, (5) classification of these bands as sequences $V'-V''=0\pm1\pm2\pm3$ which leads to a value for $D>0.5$ volts; (6) observed emission from state $V'=42$ corresponding to very high temperature molecules.

15. Observations on the fluorescence spectra of cadium vapor. W. CRAM AND J. G. WINANS, *University of Wisconsin.*—A broad band in the fluorescence of cadmium vapor has been previously observed between the limits 3050−2288A. Kapuscinski found that monochromatic light of wave-length in this band was absorbed and reemitted by the vapor. In the present experiment fluorescence was excited in cadmium vapor by light from a copper spark. The band was found to extend from 3050 to 2212A. Lines in the exciting light, of wave-length below 2288A, were reemitted by the vapor in the same manner as those observed by Kapus-

cinski. The spectrum of the electrodless discharge showed this same band but with different intensity distribution. These observations can be explained by the use of potential energy-nuclear separation curves which correspond closely to those given by Winans to interpret the absorption spectra of cadmium vapor.

16. Rotational Raman effect of gases. CHARLTON M. LEWIS, *California Institute of Technology.*—The study of the Raman effect of gases has been extended to the pure rotation of the simpler hydrocarbons. Acetylene shows the same pattern of alternating intensities that was found by Hedfeld and Mecke in absorption. Ethane and ethylene, which have the form of the symmetrical and asymmetrical top, respectively, show more complicated fine structure; but in neither case is there evidence of more than one moment of inertia. The pure rotation spectrum of methane appears to be missing, or at least of a lower order of intensity than the rotation-vibration band already found by Rasetti. The P and R branches of this band are not very much weaker than the Q branch, while another mode of vibration, which yields an extremely intense Q branch, shows no P and R branches. These characteristics are largely in agreement with what is to be expected from an extension to the rotational Raman effect of Placzek's method of treating the vibration lines.

17. Raman effect in crystalline NH_4Cl. F. T. HOLMES, *Lehigh University.*—Schaefer, Matossi, and Aderholb (Zeits. f. Physik **65,** 289 (1930)) have reported two broad Raman lines for NH_4Cl at 3155 and 3035 cm^{-1}. The author has found that in addition to these lines most of the characteristic frequencies found by Reinkober (Zeits. f. Physik **5,** 192 (1921)) in the infrared appear in the Raman spectrum as rather broad lines. However the line at approximately 1700 cm^{-1} is very sharp. In addition to these, a set of four very weak lines has been observed in the region near 3155 and 3035 cm^{-1}. In consideration of the prediction by Pauling (Phys. Rev. **36,** 430 (1930)) of rotation of the ammonium ion in this substance at room temperature, it seems possible to regard the members of this set as vibrational-rotational lines. Intensity considerations indicate that they may be associated with the 3035 cm^{-1} vibrational shift. Making these assignments, and assuming $\Delta j = \pm 2$ with no "missing lines," the moment of inertia of the rotating group is calculated to be approximately 2.0×10^{-40} gm cm^2.

18. Zeeman effect in the $^2\prod$ $^2\sum$ CaH bands. W. PEYTON CUNNINGHAM, *Yale University. (Introduced by W. W. Watson.)*—The Zeeman effect in the λ7000, $^2\Pi$ $^2\Sigma$ CaH band has been investigated at field strengths of 10,500, 18,200 and 30,000 gauss. For the Q branches the patterns are in excellent agreement with the predictions of Hill's formulas for doublet states. In the lines of the R and P branches, however, marked departures from these predicted patterns occur in the region of intermediate and high K levels. It is shown that the inclusion of the magnetic moment due to ρ, the sizeable component of l perpendicular to the internuclear axis is the Π_d levels, gives quite closely the needed corrections for these patterns. Calculation shows that for all these lines of high K values one block of components becomes so wide and diffuse as to be unobservable. Interesting variations with ρ and H in the observed narrower block of components for the region just above the crossing of the Π_d levels are discussed.

19. Zeeman effect of Pb III. J. B. GREEN AND R. A. LORING, *Ohio State University.*—The Zeeman effect of Pb III has been studied at fields of about 40,000 gausses with the newly completed 30,000 line 21-ft. Paschen-Runge concave grating set-up at this laboratory, and the same general type of vacuum box used in our work on Sn. Of particular interest in this spectrum is the $6s6p$ configuration, which seems to violate all the rules laid down by the theory. The coupling is practically j-j in type, and accurate measurements of the four lines involved in the transition $6s6p - 6s7s\ ^3S_1$ indicate that (1) the Pauli g-sum rule for the $^3P_1 + {}^1P_1$ is not accurately obeyed, the experimental value being 2.55 against the theoretical 2.50; (2) the g-value of $^3P_2$ which should be unaffected by coupling (taking into account perturbations within its own configuration) is 1.35 (exp) against 1.50 (theo.). The abnormal g-value must be attributed to perturbations by the neighboring $6p^2$ or $6s6d$ configurations.

20. Theory of quantum defect due to polarization, with application to multiplet anomalies in Al II. N. G. WHITELAW AND J. H. VAN VLECK, *University of Wisconsin.*—The formula $\Delta = (\alpha e^2 n^3/4chR)\overline{1/r^4}$ for the quantum defect Δ due to polarization is usually derived by introducing a model in which the atom-core is given *ad hoc* polarizability α. Instead a derivation is given by perturbation theory in which inter-electronic interaction is considered explicitly. The above formula for Δ is found to be valid only if exchange terms are neglected and if the absorption lines ν(A.C.) of the atom-core are large compared to those ν(V.E.) representing transitions of the valence electron. The calculation enables one to determine the "perturbations," i.e., deviations from the formula, when there is close resonance between ν(A.C.) and ν(V.E.). The theory is applied to the $3smf\ ^3F$ series of Al II, which Langer, Shenstone, and Russell have noted is perturbed by a $3p3d\ ^3F$ term. The widening of the multiplets in the vicinity of the perturbation is caused by a partial robbing of the intruders wide structure, and can be calculated from the observed displacement of the multiplet centroids from hydrogenic values. The calculated over-all widths for the successive members are 5.1, 10.8, 37.2, (58.2 for intruding $3p3d$), 20.8, 7.3, 3.7, . . . against observed 4.9, 12.3, 40.4, (58.1), 17.8, 5.7, 2.4. The discrepancies may be diminished by the further consideration of higher order approximations.

21. A theorem on spectroscopic stability. R. M. LANGER, *University of Minnesota.*—Recent spectroscopic observations, especially some of the rare gas spectra (e.g., E. Rasmussen, Zeits. f. Physik **75,** 695, 1932) bring out symmetries in the oscillations of the term values of similar series. They suggest a connection between the departures of related terms from Ritz formulae. In fact such a connection can be deduced theoretically. The rare gas series exemplify one of several possible types of behavior. The usual calculations of energy levels assuming separate configurations lead to multiplet separations and smooth series which often disagree with experimental data. Since these incomplete solutions for discrete spectra differ from the correct ones by a unitary transformation the sum of the energies of mutually perturbing configurations is correctly given by the incomplete solutions. This leads to the very useful theorem that the displacements of interacting levels from their expected positions on smooth series curves must add up to zero. The power of this stability theorem depends on narrowing down the set of levels under consideration. It will help in estimating certain large displacements of terms in series which are not well marked and will also help calculate constants for irregular series. Probably the most helpful application of the theorem will be the criterion it gives for deciding whether one has all of the set of levels which are affecting one another. The important but difficult case of continuous spectra has not been considered.

22. The escape of imprisoned resonance radiation from a gas. CARL KENTY, *General Electric Vapor Lamp Co. Hoboken, N. J.*—Theoretical considerations lead to the view that a large number of resonance quanta diffusing through a gas would, on the basis of Doppler broadening only, give rise to a distribution function for excited atoms, with respect to atomic speed, which would lie between two limiting distribution functions: (1) Maxwell's distribution function, namely

$$f_1(S)dS = [4/(\pi)^{1/2}](S^2/w^3)\exp\ -(S^2/w^2)dS$$

where S is the speed of an atom and w is the most probable speed; and (2) a distribution function expressing a lower relative excitation of the high speed atoms, namely

$$f_2(S)\ dS = 2(S/w_2)\exp - (S^2/w^2)dS.$$

On the basis of either (1) or (2) the diffusion coefficient as well as the average square free path are found to be infinite provided the volume of gas is infinite; otherwise, the *apparent* values of these quantities will depend on the volume, increasing therewith without limit because of the importance of extremely long free paths. Coupling or other broadening occuring at higher pressures will presumably accentuate the effect of abnormally long free paths. The results are in qualitative agreement with imprisonment experiments of Zemansky and of Webb and Messenger, in Hg, and with the experiments of Found and Langmuir and of Kenty in Ne (in print).

THURSDAY MORNING AT 9:00 O'CLOCK

Osborn Zoological Laboratory, Room 126

Paper No. 23, will be read by title.

23. Yield of fluorescent x-rays from the *K* shells of various elements. DONALD K. BERKEY, *University of Cincinnati.*—The fluorescent yield w from the K shells of an aggregate of atoms is defined as the ratio of the number of characteristic K quanta emitted to the number of quanta photoelectrically absorbed in the K shells. The author has measured this ratio by comparing the total intensities of the primary and fluorescent rays from various substances, using the ionization method devised by A. H. Compton (Phil. Mag. **7**, 961, 1929). The following results were obtained:

Element		w	Element		w
27	Cobalt	0.38	42	Molybdenum	0.78
28	Nickel	0.39	47	Silver	0.73
29	Copper	0.43	48	Cadmium	0.72
30	Zinc	0.46	50	Tin	0.67
33	Arsenic	0.53	51	Antimony	0.64
34	Selenium	0.56	52	Tellurium	0.60
38	Strontium	0.72			

These results show that the fluorescent yield increases to a maximum for elements in the neighborhood of molybdenum, beyond which it decreases. It is planned to continue this investigation for elements of higher atomic number than tellurium.

24. Fine structure in the x-ray *K*-absorption edge of calcium in compounds. VOLA P. BARTON, *Goucher College, and* GEO. A. LINDSAY, *University of Michigan.*—The fine structure of the Ca K edge has been examined in several calcium compounds. A quartz crystal was used and the calcium compound was ground to a fine powder and suspended in a collodion film for an absorbing screen. In cases where the calcium compound could be used as reflecting crystal and at the same time as absorber, the results were found to be the same as with screens. Calcite and aragonite, the same chemically, show markedly different fine structure, thus indicating that not the chemical compound, but rather the crystal form, is the determining factor. This is in accordance with Kronig's theory. Dolomite, $Ca\,Mg(CO_3)_2$, and ankerite, $(Ca, Mg, Fe)CO_3$ have the same crystalline form as calcite, and show the same fine structure for Ca, but the appearance for Fe in ankerite is different. This is not so satisfactory for the theory, for the iron and calcium atoms are similarly placed in the same crystal, and the ejected electron in passing through the crystal should experience the same variation in potential.

25. Further experiments on x-ray reflections from quartz crystals oscillating piezoelectrically. J. M. CORK, *University of Michigan.*—By both the Bragg method and the Laue. method, quartz crystals at rest and oscillating piezoelectrically have been further studied. Starting with a relatively thick crystal and using a finely collimated x-ray beam the structure of the Laue spots could be readily observed. For oscillating crystals and also for polished crystals at rest the spots are double in structure. Etching the crystal with H Fl results in single spots for the non-oscillating crystal. The perfection of the surface is revealed by observing line breadth and intensity when the crystal is employed in a Siegbahn vacuum spectrograph at a wave-length of 5.5A; and for short x-ray wave-lengths on a Bragg spectrometer of 55 cm radius. In no case was line breadth or intensity sensibly altered by piezoelectric oscillation of the crystal. Results obtained are compatible with the elastic vibrational theory already proposed, (Fox and Cork. Phys. Rev. **38**, 1420, (1931)).

26. X-ray wave-lengths by ruled grating. R. B. WITMER AND J. M. CORK, *University of Michigan.*—With a ruled glass grating, measurements have been made of the wave-lengths in the L series emission spectra for elements from Ti (22) to Zn (30); and in the K series for elements from C (6) to Si (14). The grating employed (whose constant was $d = .00166309$ mm) was

ruled by Siegbahn on his new machine and gave excellent reflections. The experimental arrangement was identical with that employed in the precision determination of the L series wave-lengths of molybdenum (Cork, Phys. Rev. **35,** 1456, (1930)). This method has the important advantage that for the complete series of plates the position of the grating is in no way altered. The results obtained for the shorter wave-length lines are greater by about 0.3 percent than the corresponding wave-length measurements obtained by the crystal method. Crystals that have been employed for the longer wave-length range are mica, sugar, and palmitic acid. The individual results obtained with these crystals are shown to be so erratic that a comparison with the results obtained with the grating method is meaningless. The change in the relative intensity and the form of the α_1 line with change in atomic number is shown. Additional data using different incident grazing angles are being taken to observe any possible variation in wave-length with angle of incidence. (Prins and Hanawalt, Nederlandsch Tijdschrift voor Naturkunde **12,** 1 and 15, 1932).

27. Additional theory of plane gratings for x-rays. Roy C. Spencer, *University of Nebraska.*—The positions of the diffracted virtual images of a source as seen in a plane grating placed at a distance L are given by $L' = L \sin^2\theta/\sin^2 i$ where i and θ are the grazing angles of incidence and diffraction. For use with x-rays the incident beam is confined between two equal slits of width S distant L apart with the grating close to the second slit. The diffracted beam produced backwards appears to be confined between two slits of width S' and distance L' apart where $S' = S \sin\theta/\sin i$ and L' has the value given above. The intensity of a cross section of the diffracted beam is a trapezoid, the constant part having a width S' and each side an angular width S'/L'. The former varies directly as $\sin\theta$, while the latter varies inversely. Assuming a parallel beam, the angle between the maximum and the first diffraction minimum is λ/S'. The ratio of this diffraction width to the geometrical side width is $\lambda L'/S'^2 = \lambda L/S'$, a constant of the slit system. This should not exceed unity. The combined effect of geometric and diffraction widths may be studied using a sodium flame and two slits.

28. The gamma-ray spectrometer. M. C. Henderson, *Yale University.*—The method first used by Rutherford and Andrade (Phil. Mag. **27,** 854, 1914; **28,** 263 (1914)) to measure the wave-lengths of the radium gamma-rays and later adapted by Steadman (Phys. Rev. **36,** 460 (1930)) to the Geiger point counter has been improved and some preliminary results obtained. The Geiger-Müller tube counter has been adopted as the detector. It has proved easily possible to resolve and measure the 20 and 35 x.u. radium B and C gamma-rays. With 30 mg of radium, the 35 x.u. line causes 4.7 discharges per minute out of a total of 16.5. All counting is automatic and runs 24 hours a day. The resolving power is low but it will be possible to resolve lines about 5 x.u. apart without further changes in the apparatus. The lower limit of wave-length that can be measured without disturbance from the central beam is about 20 x.u. The interrelated effects of source thickness, slit width, crystal setting and slit setting upon the theoretical gamma ray intensity transmitted through the slit can be plotted as a series of three-dimensional models, which will be shown. The method of coincidences, so successfully applied to cosmic-rays, has been tried to record gamma-rays, with encouraging results and it is being further developed. Steadman's results (loc. cit.) are not confirmed.

29. The threshold counting voltage of the Geiger-Müller tube and some related phenomena. D. Cooksey and M. C. Henderson, *Yale University.*—The voltage at which a Geiger-Müller tube begins to count is determinable to 0.1 percent. The dependence of this threshold voltage upon chamber and wire dimensions, material and nature of the surfaces, temperature of the wire, and pressure and kind of gas has been investigated. It is found that the threshold voltage for proper counting is independent of the wire and wall materials. For any chosen pressure and wire size the threshold voltage so varies with the chamber diameter that the field at the surface of the wire remains constant. This threshold field depends on the gas and its pressure, passing thru a minimum at low pressures in a similar manner to the sparking potential. Knowing the threshold field, the formula: field = voltage/(a log b/a), where a and b are the radii of the wire and chamber respectively, enables the counting voltage to be calculated for any desired dimensions and gas pressure. For small wires, less than 0.075 mm diameter, the thresh-

old field is inversely proportional to the diameter but diminishes less rapidly than this for larger wires. Raising the temperature of the wire while counting lowers the threshold voltage. One iron wire continued to count in air up to a dull red, above which temperature spurious discharges masked the proper counts.

30. New determinations of the ranges of α-particles from polonium, uranium I and uranium II. F. N. D. KURIE, *Yale University.*—The cloud chamber method described by the author in the abstracts of the New Orleans meeting (1931) has been used to determine the ranges of α-particles from polonium, uranium I and uranium II. The experiments on polonium were undertaken to test the method, but the results are in such good accord with previous values that they may stand alone. The range of polonium α particles at 0°C and 760 mm pressure is 3.69 $\pm$0.005 cm. A graphical method has been devised for separating the number-distance curves of the two uraniums, which consists in plotting the data on probability paper. The plot then becomes three intersecting straight lines, the mid point of the short connecting line giving the relative proportions of the two kinds of particles. The ranges of the uranium particles at 0°C and 760 mm pressure are respectively: $R_{U\,I}=2.58\pm0.01$ cm, $R_{U\,II}=3.11\pm0.005$ cm. The polonium range is derived from 335 tracks, the uranium ranges from 594 tracks. The uranium ranges are in complete agreement with the results of Laurence (Phil. Mag. **5**, 1027 (1928)), got by methods more likely to be in error than those used here.

31. Generalization of wave mechanics suggested by higher order terms in the classical electrodynamic equation of motion, and its influence on β-particles ionization for velocities approaching that of light. W. F. G. SWANN AND A. BRAMLEY, *Bartol Research Foundation of The Franklin Institute.*—Classical electrodynamics gives, for small velocities, an equation of electronic motion of the form

$$\frac{e}{6\pi ac^2}\times''-\frac{e}{6\pi c^3}\times'''+\text{etc.}=E+\frac{[uH]}{c} \tag{1}$$

where a is the classical electronic radius. In the present paper, the equation is solved and for the cases which are relevant gives rise to

$$\frac{e^2}{6\pi ac^2}\times''=E+\frac{[uH]}{c}+f(D)E \tag{2}$$

where $f(D)$ is a determined function of the operator d/dt. We now build a Schroedinger equation for ψ with the right-hand side of (2), replacing $E+[uH]/c$ as used in the ordinary developments, but with d/dt replaced by ∂/dt, which for the field of a high-energy β particle of velocity v becomes $-v\Delta$. The perturbation, instead of involving only the scalar and vector potentials ϕ, and $\vec{u}$, which can be expressed in terms of it, involves also a series of spatial derivatives of ϕ. Application to the ionization of an atom gives for q the number of ions per centimeter of path, an expression which, with increasing β-particle energy, first diminishes, then increases, and finally diminishes towards zero. The first decrease followed by increase corresponds to the conclusions of Oppenheimer, as yet apparently unpublished. The final decrease comes from the new features introduced. It predicts a decrease of ionization for β-particle energies greater than about 10^{10} volts.

32. An interpretation of cosmic-ray phenomena. THOMAS H. JOHNSON, *The Bartol Research Foundation of the Franklin Institute, Swarthmore, Pa.*—Schindler's measurements form the basis for a more specific theory of the process of ionization by cosmic rays than had hitherto been possible. To explain his data the following assumptions are made. (1) The primary rays contribute nothing *per se* to the ionization but produce secondary rays such as electrons and protons from the material through which they pass, the production coefficient β_m being a characteristic of the medium. (2) The absorption of the primary rays can be represented by a single exponential function with a coefficient ν_m characteristic of the medium. (3) The absorption of the secondaries can be represented by an exponential function, with a coefficient $\mu_m{}^n$ which is

characteristic of both the absorbing medium m and the medium n in which the secondary ray was produced. The ionization at distance x behind the interface nm is given by

$$I = \frac{A\beta_m}{\mu_m{}^n - \nu_m}(e^{-\gamma_m x} - e^{-\mu_m m}) + Be^{-\mu_m n x}.$$

The constants have been determined to bring agreement with the data in the case of the air to lead, air to iron, iron to lead, and lead to iron transitions. The absorption coefficients of the secondary rays determined in this way agree with the energies measured by Millikan and Anderson. The relation of these ideas to other experiments is also discussed.

THURSDAY MORNING AT 9:00 O'CLOCK

Osborn Zoological Laboratory, Room 360

Papers No. 33, 39 will be read by title.

33. Study of getter action of phosphorus. HENRY J. MILLER, *Emporium, Pa.*—The clean-up of commercial 50 watt 230 volt vacuum incandescent lamps by phosphorus has been investigated and compared with the clean-up in lamps of the same type evacuated by laboratory methods by means of a third external electrode measuring the ratio of positive ions to electrons flowing to this electrode while the filament voltage is gradually raised from zero to a value somewhat above normal rating. The clean-up initiated by the thermionic current flowing between filament terminals progresses with maximum efficiency at filament potentials which, for lamps with getters, agree with the volt value of maximum ionization efficiency of 150 volts found by Mayer for air and nitrogen (Ann. d. Physic **45,** 1 (1914)). Commercial lamps without getters do not clean up. Lamps without getters evacuated by laboratory methods clean up but at higher potentials than the corresponding lamps with getters (175 to 200 volts). The clean-up curves of lamps with getters and without getters suggest the interpretation of the observed clean-up as "chain-reaction" according to Bodenstein. (*Preuss. Akad. Wiss. Phys. Math. Kl.* 1928, p. 490).

34. The Kerr electro-optical effect in carbon dioxide. C. W. BRUCE, *University of Virginia, (Introduced by J. W. Beams).*—Measurements have been made on the variation with density of the Kerr electro-optical effect in CO_2 using a method similar to that of Stevenson and Beams (Phys. Rev. **38,** 133 (1931)). The measures were taken at a constant temperature of 34.6°C. The density was varied from 0.05 to 0.288 gm/cc and was computed from pressure readings by use of Amagat's data. The results of Stevenson and Beams were confirmed for the range (0.08−0.18) over which they worked. A comparison made between the variation of the Kerr constant as determined experimentally and as computed from the relation $B \propto [(n^2+2)^2(\epsilon+2)^2]/n$, taken from the Langevin-Born theory, shows good agreement. The data for the index of refraction used in the above relation were that of Phillips (Proc. Roy. Soc. **A97,** 225 (1920)), and for the dielectric constant was that of Keyes and Kirkwood (Phys. Rev. **26,** 754 (1930)).

35. The initiation of electrical discharges in effectively ion free gases. J. W. BEAMS AND JOHN W. FLOWERS, *University of Virginia.*—A study is made of the factors that initiate the discharges described by Street and Beams (Phys. Rev. **38,** 416, (1931)). In carefully dried and filtered gases (air, hydrogen, nitrogen, helium) at atmospheric pressure, it is possible to apply 5×10^5 volts per cm between spherical brass electrodes for 10^{-6} sec. without electrical breakdown, provided the gas is kept "swept" as free as possible of ions by auxiliary fields. However, when ultraviolet light falls upon the cathode a field of 4×10^4 volts per cm starts the discharge in less than 10^{-7}sec. The maximum field depends upon the conditions of the surface of the electrodes and is of the same order of magnitude as that required to produce breakdown in a vacuum, which is known to be started by field currents from the cathode (Wood, Phys. Rev. **5,** 1 (1897); Hull and Burger, Phys. Rev. **31,** 1121 (1928); Snoddy, Phys. Rev. **37,** 1678 (1931)).

When a steel point and plane were substituted for the brass spheres in the above experiment the field at the surface of the point could be made at least 10^7 volts per cm for 10^{-6} sec. without breakdown if the point was positive. However, breakdown started in less than 10^{-6} sec. if the point was made the cathode and the field raised to only 10^6 volts per cm. In a vacuum fields of 8×10^7 volts per cm were applied to the pointed steel or tungsten anode for 10^{-7} sec. without breakdown. Similar results were obtained with gaseous pressures less than 0.01 mm.

36. Ionization of helium, neon and argon under impact of their own positive ions. CHARLES J. BRASEFIELD, *Yale University.*—The number of electrons liberated from neutral rare gas atoms under impact of their own positive ions was measured as a function of the kinetic energy of the ions. It was found that helium was ionized at 100 equivalent volts; neon at 90 and 130 volts; and argon at 55 and 95 volts. It is thought that the higher ionizing potentials in the case of neon and argon are the result of impacts of doubly charged ions. The error in these measurements is hard to estimate but is thought to be within ± 10 volts. If we assume (1) that half of the kinetic energy of the impacting ion is available for ionization and (2) that the energy required to liberate an electron is approximately the sum of the energies necessary to liberate it separately from its own core and from that of the impacting ion, we might expect ionization of the rare gases under impact of their own positive ions to occur at approximately the following values: in helium at 98 volts, in neon at 86 and 125 volts and in argon at 63 and 87 volts.

37. New devices for recording Kennelly-Heaviside layer reflections. HARRY R. MIMNO AND P. H. WANG, *Harvard University.*—Two new pieces of apparatus for layer height measurement have been built and tested. The first device is merely an improved form of the "long film" type of oscillograph, ordinarily used in pulse transmission experiments. In order to increase the resolving power without wasting or tearing the photographic paper tape, the oscillograph has been constructed with a magnetic clutch, shock absorber, and magnetic brake. The second device is a high speed chronograph, designed to give an accurate record of layer heights over an extended period of time. A complete history of the reflections produced by 2000 successive pulses is recorded in compact form on a strip of photographic paper, 90 cm long and 12 cm wide. The time scale may be varied from 5 minutes to 24 hours. The received pulses modulate a glow lamp, producing a small, sharply-defined dot on the moving paper. The resolving power appears to be somewhat better than that obtained with the best galvanometer oscillographs. A cathode-ray oscillograph is used to monitor the reception. The high speed chronograph has other applications, outside of the radio transmission field.

38. A new type of vacuum or circulating pump. E. L. HARRINGTON, *University of Saskatchewan.*—A new type of vacuum or circulating pump employing a helical tube made to rotate about the axis of the helix is described. Its action depends on a pumping liquid which fills the lower bends of the helix and crowds out the gas being pumped as the helix is rotated. There is a provision for the return of the pumping liquid to the first coil of the helix as the latter continues to rotate. The liquid may be chosen to suit the work at hand. Among the advantages claimed for the pump are the following: mercury vapour is not employed, heating and cooling elements are not required, adapted equally well to corrosive and non-corrosive gases, vapors and liquids, constant personal attention is not needed, it may be started or stopped instantly without the use of stop-cocks, and its action is reversible.

39. The form of potential barrier at the surfaces of conductors. A. T. WATERMAN, *Yale University.*—The method of treatment described by the writer (Phys. Rev. **38**, 1497–1505 (1931)) has been used to investigate the form of potential barrier inside as well as outside the surface of a conductor in equilibrium with its electron atmosphere, assuming continuity of potential and electric intensity at the boundary. The results indicate that there is a sharp rise in the barrier of about 4 or 5 volts within a distance of several Angstrom units in the immediate neighborhood of the surface (assumed plane). About one fifth of the rise occurring inside the conductor. The rest of the potential curve rises more gradually. Similar treatment for the form of barrier between plane parallel electrodes shows this to consist of a potential "plateau." To be consistent with contact potential as defined by the Kelvin experiment, on bringing the electrodes together there is a flow of electrons into the less electropositive metal, the potential

barrier becomes a "hill" of decreasing height, until it disappears in a point of inflection at contact. Similarly the potential "trough" within a thin conducting film flattens out and disappears as the thickness of the film approaches zero. The case of a thin film deposited on base metal is difficult to solve, but gives promise of accounting for some of the peculiarities observed in such cases.

40. The caesium-oxygen-silver photoelectric cell. C. H. PRESCOTT JR. AND M. J. KELLY, *Bell Telephone Laboratories Inc.*—The active cathode surface of the caesium-oxygen-silver photoelectric cell appears to be a film or surface concentration of caesium of atomic dimensions adsorbed upon a matrix of caesium oxide and silver containing free caesium and a small amount of silver oxide. The spectral characteristics of the photoelectric response depend largely upon the thickness of the surface film of free caesium. This film thickness is determined by the caesium concentration in the underlying matrix and is maintained by a diffusion equilibrium. Variations in the amount of caesium upon the surface were made either by exposing the standard finished cathode to small amounts of oxygen and allowing the response to recover by diffusion of free caesium from the underlying material, or else by allowing small amounts of additional caesium to deposit upon the standard surface. With increasing thickness of the caesium surface film the characteristics of the spectral response appear to vary continuously from a low response (with amounts of surface caesium far below the normal) which decreases with wave-length (from 6,000A to 10,000A) to a high response for the normal surface with a selective maximum at 7,500A−8,000A ,and finally to a low response with a maximum approaching 6,000A.

41. Some photovoltaic properties of Cu:Cu_2O |$Pb(NO_3)_2$ solution| Cu:Cu_2O photocells. WILBUR E. MESERVE, *Cornell University* (*Introduced by Ernest Merritt*).—The light sensitive electrodes were prepared by chemical methods which produce a uniform coating of copper oxide of any desired thickness. Two identical electrodes were placed in a 1 percent solution of $Pb(NO_3)_2$, the back of the light exposed electrode being insulated from the electrolyte. Measurements were made of the photo-e.m.f. produced by the cell when illuminated by sinusoidally interrupted light of variable frequency. By impressing the output of the cell on a resistance coupled amplifier of proper design, which takes no current from the cell and thus reduces polarization and internal chemical changes to a minimum, the frequency response was determined with the use of the stabilized cathode-ray "oscilloscope." The spectral sensitivity of the cells was determined with sinusoidally interrupted light from a monochromator and checks with that which has been determined with steady illumination. The angle of phase shift of the photo-e.m.f. with respect to the interrupted light was also measured and was found to first increase and then decrease with frequency, the maximum angle occurring at about 500 cycles. The internal capacity of the cell as an electrolytic condenser was found to nearly double when one electrode was illuminated by strong sunlight.

FRIDAY MORNING AT 8:00 O'CLOCK

Osborn Zoological Laboratory, Room 102

SYMPOSIUM

on

"X-Rays"

INVITED PAPERS

1. **Wave-Length of Scattered Radiations.** J. A. GRAY, *Queen's University.*
2. **Experimental Evidence for High Electron Momenta in Atoms and in Solid Bodies.** J. W. M. DUMOND, *California Institute of Technology.*

3. **Status of X-Ray Wave-Lengths.** J. A. BEARDEN, *Johns Hopkins University.*

4. **Fine Structure of the K-Absorption Edge.** J. D. HANAWALT, *The Dow Chemical Company.*

Discussion: led by BERGEN DAVIS.

SATURDAY MORNING AT 8:30 O'CLOCK

Osborn Zoological Laboratory, Room 102

Joint Session of the American Physical Society and the American Society of Mechanical Engineers

SYMPOSIUM

on

"Plasticity"

George B. Pegram, presiding

INVITED PAPERS

1. **Mosaic Structure of Crystals.** F. ZWICKY, *California Institute of Technology.*

2. **Magnetism and Plasticity.** F. BITTER, *Westinghouse Electric and Manufacturing Company.*

3. **Dissipational Resistance to Distortion in Solid Bodies and its Correlation with other Physical Properties.** R. L. WEGEL AND H. WALTHER, *Bell Telephone Laboratories, Inc.*

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program, to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for at the Thursday morning session, Sloane Physics Laboratory, Room 56.

SECOND NATIONAL APPLIED MECHANICS MEETING

The American Society of Mechanical Engineers

June 23–25, 1932, New Haven, Conn.

Yale University

PROGRAM

Eastern Standard Time

THURSDAY, JUNE 23, 1932

7:00 A.M. REGISTRATION OPENS, Hotel Taft.

There will be a one dollar registration fee.

9:00 A.M. Hydro- and Aerodynamics Session, Sloane Physics Laboratory

Chairman: DR. LYMAN J. BRIGGS, Chief, Mechanics and Sound Division, Bureau of Standards, Dept. of Commerce, Washington, D. C.

Resistance of Slender Bodies Moving with Supersonic Velocities. DR. TH. VONKARMAN AND N. B. MOORE, *California Inst. of Tech., Pasadena, Calif.*

On the Lift Distribution for a Wing of Arbitrary Plan Form in a Circular Wind Tunnel. C. B. MILLIKEN, *California Inst. of Tech., Pasadena, Calif.*

On the Buckling Strength of Columns with Elastic Intermediate Supports. DR. W. KLEMPERER, Manager of Research, *Goodyear-Zepplin Corp., Akron, O.* (By title.)

Film—On a New Kind of High Speed Water Craft. O. TIETJENS, Research Engineer, *Westinghouse Elec. & Mfg. Co.*

1:00 P.M. Vibration Session, Sloane Physics Laboratory

Chairman: P. G. LAURSON, Professor, Yale University.

Vibration During Acceleration through a Critical Speed. F. M. LEWIS, *Webb Inst. of Naval Architects, New York, N. Y.*

Self Induced Vibrations. J. G. BAKER, Research Engr., *Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.*

Critical Torsional Oscila, of Rotating Accelerating Shafts. DR. M. BIOT, *California Inst. of Tech., Pasadena, Calif.*

Vibration with Velocity Damping. M. STONE, Engineer, *Westinghouse Co., East Pittsburgh, Pa.* (By title, or presented if time permits)

Vibration of a System with Two Degrees of Freedom Analyzed by Vector Diagrams. J. L. MANSA, *Lafayette College, Easton, Pa.* (By title.)

Calculation of the Stresses Occurring in a Building During an Earthquake. DR. M. BIOT, *California Inst. of Tech., Pasadena, Calif.* (By title.)

3:30 P.M. Inspection of Sterling Memorial Library Hall, including Tea.

5:30 P.M. Joint Dinner and Performance at the University Theater.

FRIDAY, JUNE 24, 1932

8:30 A.M. Stress Analysis Session, Sloane Laboratory

Chairman: C. J. TILDEN, Professor, Yale University.

Bending of Long Rectangular Plates with Lateral Loading. S. WRAY, *Univ. of Mich., Ann Arbor, Mich.*

Strength of Semi-Circular Plates and Rings under Uniform External Pressure. A. M. WAHL, Research Engineer, *Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.*

Shearing Stresses in Torsion and Bending by Membrane Analogy. P. A. CUSHMAN, *University of Michigan, Ann Arbor, Mich.*

Concentration of Stress Round Spherical and Cylindrical Inclusions and Flaws. DR. N. GOODIER, *Ontario Research Foundation, Toronto, Can.*

The Design of Columns of Varying Cross Sections. DR. A. N. DINNIK, *Russia.* (By title.)

1:00 P.M. Elasticity and Plasticity Session, Sloane Physics Laboratory

Chairman: DR. THEODOR VON KARMAN, California Institute of Technology.

Creep of Metals. DR. A. NADAI, Research Engineer, *Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.*

The Elastic Behaviour of Vulcanized Rubber. H. HENCKY, *Massachusetts Institute of Tech., Cambridge Mass.*

Creep in Bending. G. MACCULLOUGH, *Univ. of Michigan, Ann Arbor, Mich.*

Stress Distribution in a Re-entrant Corner. J. H. A. BRAHTZ, *California Inst. of Tech., Pasadena, Calif.* (By title.)

The Distribution of Pressure Concentrated on a Small Surface. M. A. SADOWSKY, *Univ. of Minnesota, Minneapolis, Minn.* (By title.)

Distribution of Stress Due to a Single Force Acting on the Edge of a Circular Hole, etc. W. O. RICHMOND, Research Engineer, *Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.* (By title.)

The above three papers will be discussed in this session if time permits. If not, then they will be discussed in Saturday afternoon session.

Solution of Problem of Plane Strain in Bending. J. M. KLITCHIEFF, *Belgrade, Yugo-Slavia.* (By title.)

4:00 P.M. Joint Outing, Sea Bathing, Sports, Picnic, Dinner, Dancing

(Should weather not permit outing, the Thermal Stresses Session scheduled for Saturday afternoon will be held at 8:00 P.M. at the Sloane Physics Laboratory.)

SATURDAY, JUNE 25, 1932

8:30 A.M. Joint Session with American Physical Society, Sloane Physics Laboratory

Chairman: G. B. PEGRAM, Professor, Columbia University, Chairman, A. S. M. E. Applied Mechanics Division, and Treasurer, The American Physical Society.

Mosaic Crystals Structure. DR. F. ZWICKY, *California Inst. of Tech., Pasadena, Calif.*

Magnetism and Plasticity. DR. F. BITTER, Research Engineer, *Magnetic Division, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.* (No advance copies.)

Dissipational Resistance to Distoriton in Solid Bodies and its correlation with other Physical Properties. R. L. WEGEL AND H. WALTHER, Research Engineers, *Bell Telephone Laboratories, New York, N. Y.* (No advance copies.)

1:00 P.M. Thermal Stresses Session, Sloane Laboratory

Chairman: C. J. TILDEN, Professor, Yale University.

Thermal Stresses in Spheres and Cylinders Produced by Temperatures Varying with Time. C. H. KENT, Professor, *The Pennsylvania State College, State College, Pa.*

A Study of the Change of Shape of a Corrugated and a Pressed Pipe Bend Under Transverse Loading. E. T. COPE AND E. WERT, Research Engineers, *Detroit Edison Co., Detroit, Mich.*